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(54) **Optical pickup device**

(57) The objective lens 20 of an optical pickup device has an intermediate region A2 with a curvature differing from the curvature of central and peripheral regions A1, A3. The curvature of the central and peripheral regions is an optimized value which reduces spherical aberration when scanning a thin disk 30a eg a DVD. The curvature of the intermediate region is an optimized value which reduces spherical aberration when scanning a thick disk 30b eg a CD.

FIG. 4

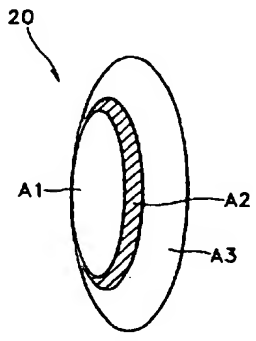

FIG. 3

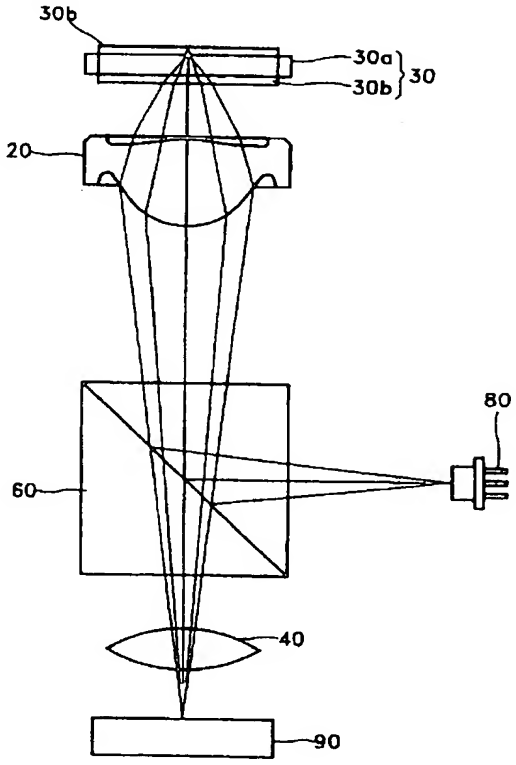

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FIG. 1
(PRIOR ART)

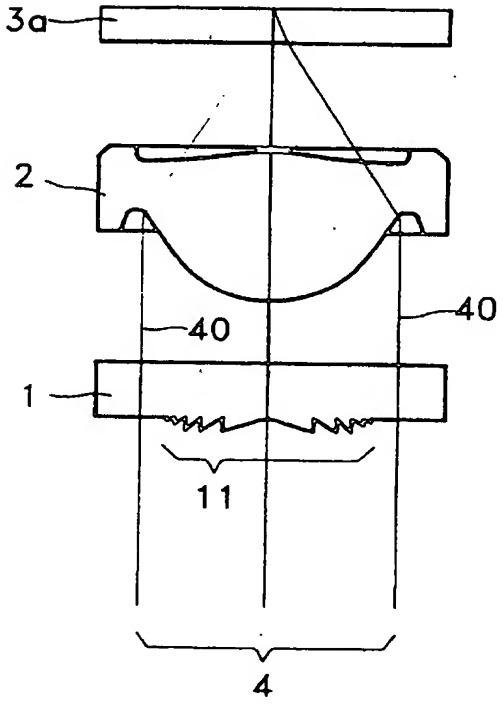


FIG. 2
(PRIOR ART)

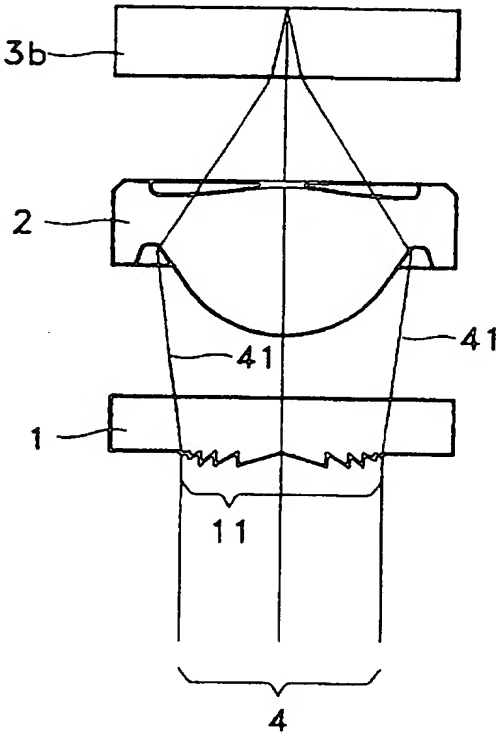


FIG. 3

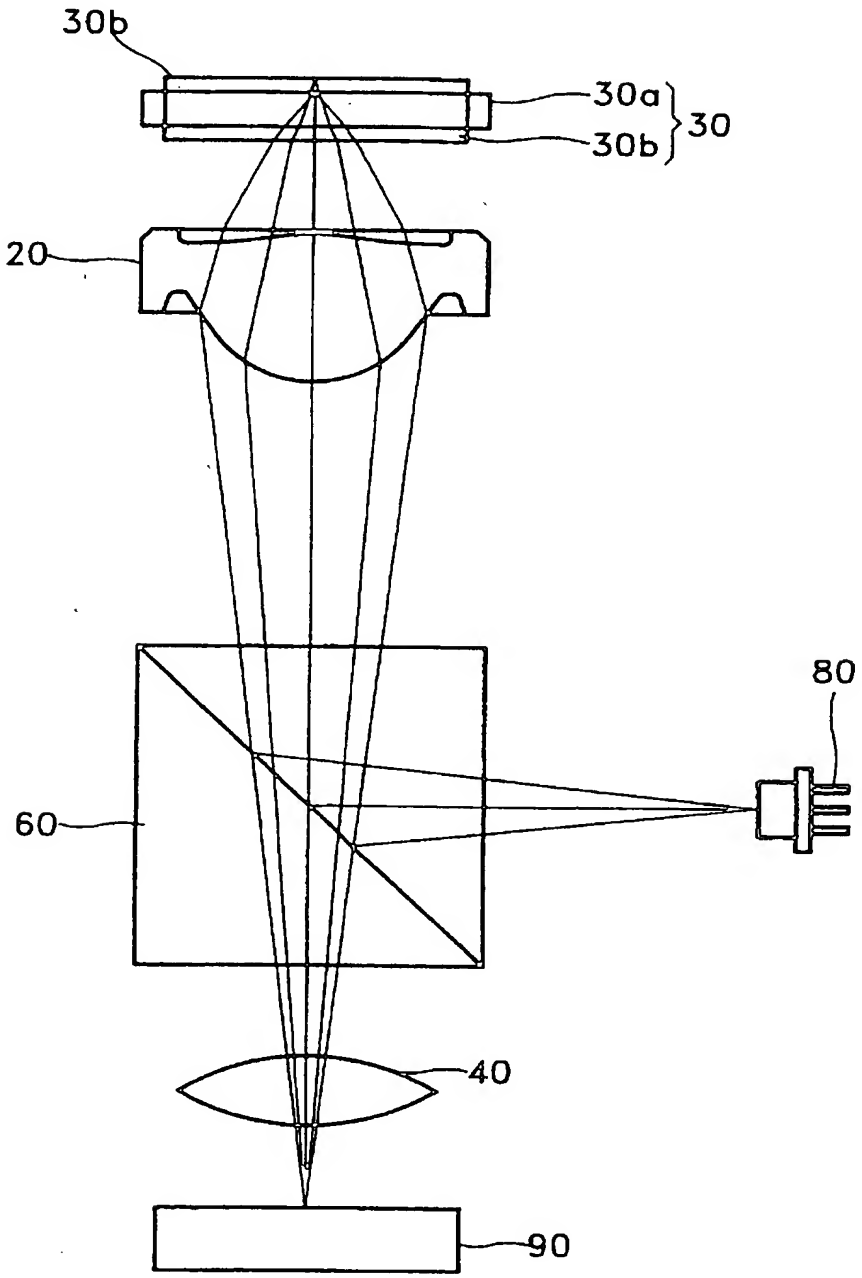


FIG. 4

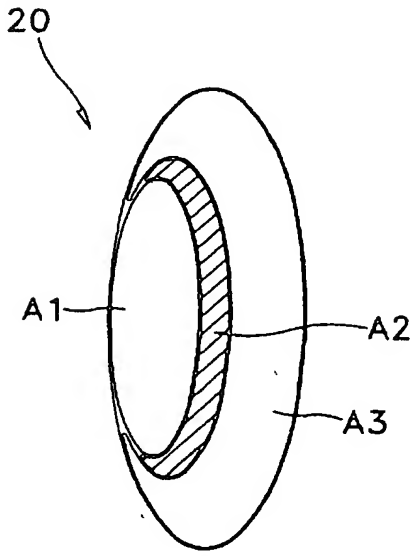


FIG. 5

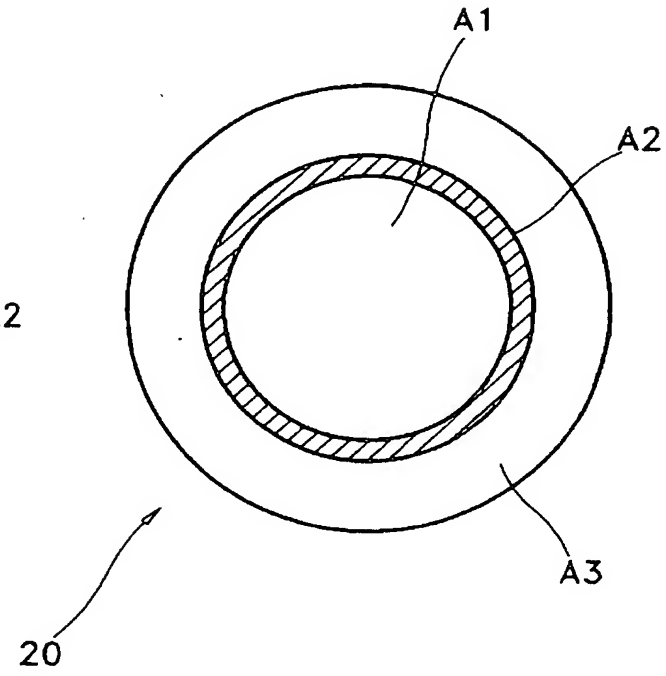


FIG. 6

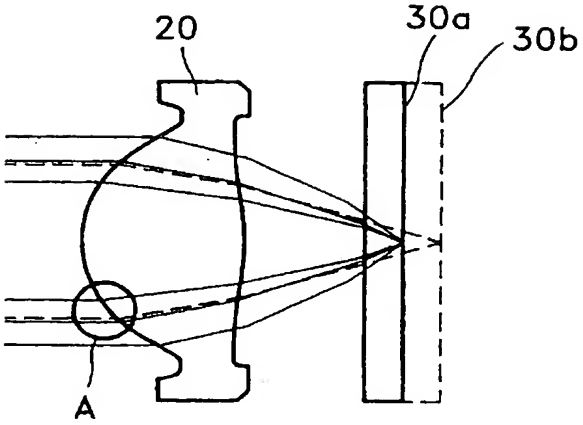
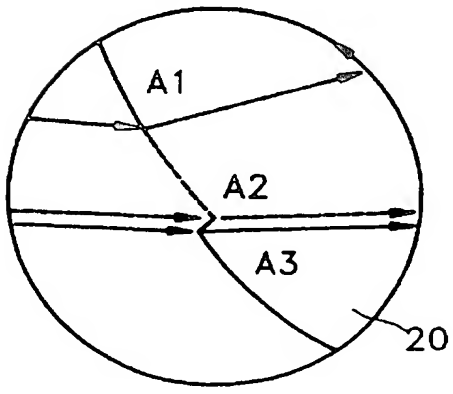

20
30a
30b
A
REPRODUCTION FROM THIN DISK
REPRODUCTION FROM THICK DISK

FIG. 7


A1
A2
A3
20

OPTICAL PICKUP DEVICE

The present invention relates to an optical pickup device which is applied to an optical pickup apparatus, and more particularly, to an optical pickup device which enables reading out of information from optical disks having different thicknesses and enables recording information thereon.

In the optical pickup, an objective lens faces a recording surface of an optical disk for focusing light to record information onto the recording surface of the disk or receiving light reflected from the surface of the disk to read information.

Recently, research on an optical drive has been conducted in which the drive can seat disks having different thicknesses by adopting a lens device including both a hologram lens and a refractive lens.

Figures 1 and 2 show focusing states of a conventional optical pickup device of light incident by zero order diffracted light and 1st order diffracted light on a thin disk and a thick disk, respectively. A refractive lens 2 and a hologram lens 1 are disposed in sequence along an optical path from each of disks 3a and 3b. The hologram lens 1 has a lattice pattern 11 for diffracting light that passes through the hologram lens 1. Thus, while light 4 emitted from a light source (not shown) passes through the hologram lenses 1, light is divided into a diffracted 1st order light 41 and a non-diffracted zero order light 42, respectively. While the diffracted 1st order light 41 and the non diffracted zero order light 40 pass through each of objective lenses 2, the light 41 and 40 are focused with different

intensities, thereby forming a focus on the thin disk 3a and on the thick disk 3b.

The lens device described above can record information on disks having different thicknesses and read out information therefrom using zero order light and 1st order light. However, as the incident light is divided into zero order light and 1st order light, the efficiency of light use is lowered. That is, since the incident light is divided into zero order light and 1st order light by the hologram lens 2, the actual amount of light used for recording information is only 15%. Also, when information is reproduced, information is included in only one of zero order light and 1st order light. Thus, 1st order light or zero order light without information is detected by a photo detector and the detected light may produce noise. The above problem can be traversed by processing the hologram lens of the lens device. However, this requires a high precision process of etching a fine pattern on the hologram, thereby increasing the manufacturing cost.

It is an aim of embodiments of the present invention to provide an optical pickup device wherein parts thereof can be manufactured and assembled easily at low cost.

It is another aim of embodiments of the present invention to provide an optical pickup device which has high efficiency of light use and low spherical aberration.

According to a first aspect of the invention, there is provided an optical device comprising: a light source; an objective lens facing a disk having a light passing region divided into central, intermediate and periphery regions respectively corresponding to a near axis area, an

intermediate axis area and a far axis area of incident light, wherein the curvature of the central and peripheral regions are optimized for a thin disk and that of the intermediate region is optimized for a thick disk; a photo detector for detecting light reflected from the disk; a beam splitter, disposed between the objective lens and the light source, for transmitting/reflecting light from the light source toward the objective lens and for reflecting/transmitting light reflected from the disks toward the photo detector.

Preferably, said photo detector receives light only in the near and intermediate axis areas for reproducing information from the thick disk.

Preferably, the intermediate region of said objective lens is in a ring shape.

Preferably, the intermediate region is formed in at least one side of said objective lens.

The above objects and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

Figure 1 is a schematic diagram of a conventional lens device having a hologram lens focusing on a thin disk;

Figure 2 is a schematic diagram of the lens device of Figure 1 focusing on a thick disk;

Figure 3 is a schematic diagram of an optical pickup device according to a first embodiment of the present invention;

Figures 4 and 5 are perspective and front views of an objective lens suitable for adoption into the optical pickup device;

Figure 6 is a diagram showing an optical path through the objective lens of the optical pickup device according to embodiments of the present invention; and

Figure 7 is a magnified view of portion *A* in Figure 6.

According to an optical pickup device of embodiments of the present invention, in order to prevent the generation of spherical aberration from light of an intermediate area when information is reproduced from a thick disk (the intermediate area being located between a near area and a far area, relative to a central optical axis), the curvature of an intermediate region corresponding to the intermediate area of the light is optimized with respect to the thick disk. Also, the light receiving area of a photo detector is limited so that light of the far axis area cannot be reached thereto when information is reproduced from the thick disk. Here, the near axis area represents an area around a central axis of the lens with negligible aberration. Also, the far axis area represents an area relatively far from the optical axis compared with that of the near axis area, and the intermediate area represents an area between the near and far axis areas.

Figure 3 is a schematic diagram of an optical pickup device according to the present invention. Like a general optical pickup device, an objective lens 20, a beam splitter 60 and a detecting lens 40 are disposed in sequence on an optical path between a disk 30 and a photo detector 90, and a light source 80 is located on another optical path from the beam splitter 60.

In the optical pickup device having the above structure, the objective lens 20 is characterized as shown in Figures 4 and 5.

The objective lens 20 has a doughnut- or ring-shaped intermediate region *A2* on at least one side, having outer diameter which is less than total significant light passing area diameter. Also, a central region *A1* and a periphery region *A3* are placed inside and outside of the intermediate region *A2*, respectively. Here, the curvatures of the central and peripheral regions *A1* and *A3* are optimized for a thin digital video disk (DVD), and that of the intermediate region *A2* is optimized for a thick compact disk (CD). Also, depending on circumstances, the intermediate region *A2* may be divided into a plurality of subregions. Preferably, the photo detector 90 is designed for only receiving light passed through the central and intermediate regions *A1* and *A2* of the objective lens 20 when information is reproduced from the thick disk, in which light of the far axis area is not detected by the photo detector 90.

Thus, as shown in Figures 6 and 7, when information is reproduced from the thick CD 30b, only light inside the dashed line is focused on the thick CD 30b. Here, since light of the near axis area passes through the objective lens, less spherical aberration is generated, even though

the curvature of the central region *A1* corresponding to the near axis area is optimized for the thin DVD 30a. Also, when reproducing information from the thin DVD 30a, light passes through the central and peripheral regions *A1* and *A3* whose curvature is optimized for the thin disk, thereby forming a focus on a surface including information of the thin disk 30a.

When a numeric aperture (NA) of the regions corresponding to the near and intermediate axis areas is less than 0.4, a small focus can be formed on the thick disk, wherein the small focus is optimized for the CD disk. According to experimentation, it is preferable that the width of the ring-shaped intermediate region is greater than 50μm from the thin disk for a stable reproducing characteristic. Also, the data of the objective lens for each region which is optimized for the CD and DVD are summarized in Tables 1 and 2.

As described above, both the thick CD and the thin DVD can be compatibly adopted and a signal can be detected without picking up noise regardless of the thickness of the disk. Also, the objective lens can be manufactured easily by a general compression or injection moulding, thereby lowering manufacturing costs.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and

drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Table 1 - Data at the intermediate region of the objective lens.

Curved Surface	Curvature	Thickness	Refractive Index	Aspherical Coefficient
Front	2.40632	2.600000	1.505	K = 0.00000 A = -3.51258E-03 B = -6.19938E-04 C = -2.32191E-04 D = 0.00000
Back	-5.11700	1.563295	1.580	K = -24.72000 A = 4.46350E-03 B = -3.69750E-03 C = 8.23880E-04 D = -7.45950E-05
Disk	∞	1.200000	1.550	Not Applicable

Table 2 - Data at the central and periphery regions

Curved Surface	Curvature	Thickness	Refractive Index	Aspherical Coefficient
Front	2.09200	2.600000	1.505	K = -0.872110 A = 4.79500E-03 B = 6.25260E-05 C = 1.24380E-05 D = -1.76880E-04
Back	-5.11700	1.563295		K = -24.72000 IC : Yes CUF = 0.000000 A = 4.46350E-03 B = -3.69750E-03 C = 8.23880E-04 D = -7.45950E-05
Disk	∞	0.600000	1.550	Not Applicable

CLAIMS

1. An optical pickup device comprising:

a light source;

an objective lens facing a disk having a light passing region divided into central, intermediate and periphery regions respectively corresponding to a near axis area, an intermediate axis area and a far axis area of incident light, wherein the curvature of the central and peripheral regions are optimized for a thin disk and that of the intermediate region is optimized for a thick disk;

a photo detector for detecting light reflected from the disk;

a beam splitter, disposed between said objective lens and said light source, for transmitting/reflecting light from said light source toward said objective lens and for reflecting/transmitting light reflected from the disks toward said photo detector.

2. The optical pickup device as claimed in claim 1, wherein said photo detector receives light only in the near and intermediate axis areas for reproducing information from the thick disk.

3. The optical pickup device as claimed in claim 1, wherein the intermediate region of said objective lens is in a ring shape.

4. The optical pickup device as claimed in claim 1, wherein the intermediate region is formed in at least one side of said objective lens.

5. An optical pick-up device substantially as herein described with reference to Figures 3 to 7.